

Surface Circulation in the Northeastern Mediterranean (NEMED)

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http://poseidon.ogs.trieste.it/sire/drifter/nemed_main.html

LONG-TERM GOALS

To investigate the dynamics of semi-enclosed seas dominated by buoyancy input and wind forcing, and influenced by complex topography. To improve the understanding of coastal marine environmental evolution, with particular emphasis on eddy dynamics.

OBJECTIVES

The main goal on the NEMED project is to measure the surface currents in the Eastern Mediterranean Sea with particular focus to the eastern and northern areas of the Levantine sub-basin and to validate (or not) circulation patterns published in the literature based on in-situ observations (CTD and AXBT), remote sensing data (SST and sea surface topography) and models. It is proposed to use low-cost satellite-tracked drifters to measure currents in the near-surface mixed-layer. The monitoring of the circulation in the Northeastern Mediterranean, with main focus on the currents trapped on the topographic slope and on sub-basin and mesoscale eddies, is planned for a full year in order to investigate any seasonal variability. The surface current observations will be interpreted in concert with the distribution of tracers (SST, chlorophyll, etc.) measured from satellites.

APPROACH

The following tasks will be performed:

- Literature review of the Levantine Sea oceanography.
- Procurement and deployment of SVP (GDP) drifters with Argos data telemetry and positioning. Seasonal deployments of drifters are planned starting in summer 2009 in three geographical areas: south of Cyprus, east of Israel and south of the Turkey with the help of local oceanographers.
- Drifter data management in both near-real time (processing and posting on the web) and delayed-mode (creation of a database updated every three months). Acquisition of satellites images for the Northeastern Mediterranean (SST and ocean color).

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- Statistical analyses using the drifter velocity data: mean circulation and eddy variability maps for the different seasons and wind regimes, Lagrangian statistics (integral time and length scales and eddy diffusivities). Qualitative description of the circulation using drifter and satellite data (creation of images and animations with color-coded SST/chlorophyll fields overlaid with drifter tracks).

WORK COMPLETED

Drifter deployments in the Levantine Sea were conducted by our collaborators in Israel and Cyprus until August 2010, including the following deployment episodes:

- 3-4 December 2009, 4 drifters south of Cyprus during the sailing boat TARA expedition;
- 25 November 2009, 3 drifters off the Israeli coast;
- 10 March 2010, 3 drifters off the Israeli coast;
- 19 May 2010, 4 drifters on transect Limassol (Cyprus) – Haifa (Israel);
- 15 June 2010, 4 drifters on transect Limassol (Cyprus) – Port Said (Egypt);
- 11 August 2010, 3 drifters off the Israeli coast.

Unfortunately, the deployments originally planned south of Mersin (Turkey) were not conducted because the drifters were seized by the Turkish Customs authorities in Istanbul.

As of 30 September 2010, 2 drifters are still operational in the Levantine Sea, moving westward north of the Nile River delta. In total, 31 drifters were deployed in the Levantine Sea since July 2009. More than 1500 drifter-days worth of data were collected.

The NEMED web pages were updated. They provide basic information on the project, near real time (updated on a daily basis) products such as graphs with drifter trajectories and with time series of position (latitude and longitude, speed, sea surface temperature, battery voltage, drogue presence parameter, etc.). A status table is also included to monitor the drifter array. The drifter positions have also been implemented in Google Earth (see Figure 1). The URL address of the NEMED main page is: http://nettuno ogs.trieste.it/sire/drifter/nemed/nemed_main.html

All the drifter data were processed (editing, optimum interpolation, low-pass filtering) and archived in a database. This web-based database includes final descriptions of the observational work, final graphical representations and statistical summaries of the processed data, and data files in MATLAB binary format (<http://nettuno ogs.trieste.it/sire/drifter/database/NEMED/>).

Pseudo-Eulerian statistics of the near-surface circulation were calculated using bins of 0.5 x 0.5. The mean near-surface circulation derived from the drifter velocities is depicted in Fig. 2

Drifter tracks were overlaid on satellite images of sea surface temperature, chlorophyll concentration and sea surface height to describe qualitatively the spatial structure and temporal evolution of the Levantine Sea dynamics. An example is illustrated in Fig. 3.

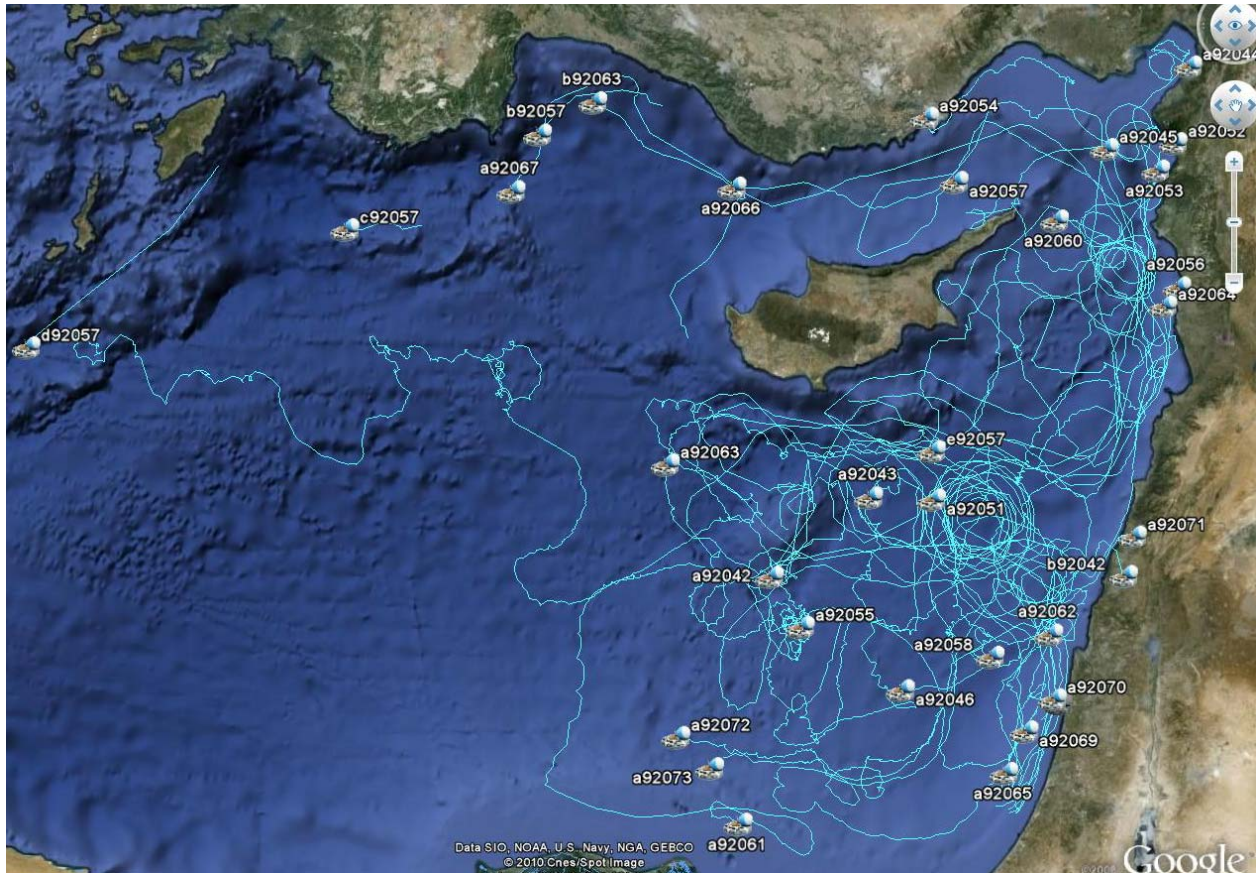


Figure 1. Trajectories of the drifters in the eastern Levantine sub-basin. Drifter identification numbers are posted at the end of the tracks. As of 30 September 2010, two drifters (a92072 and a92073) were still transmitting north of the Nile River delta.

RESULTS

The drifters put in evidence a strong coastal current flowing northward along the coasts of Israel, Lebanon and Syria. This current can create instability features shown as loops in the drifter trajectories (Fig. 1). In particular, all the drifters deployed off Israel were deviated offshore and got trapped in an anticyclonic eddy northwest of Haifa (also called the Shikmona anticyclone, see Figs. 1 and 3). This circulation feature moved subsequently to the northwest and entrapped 2 drifters as long as more than a month. The diameter of this eddy is about 50 km, the period of rotation is about 6 days and typical speeds are 50 cm/s. It is clearly a warm-core eddy well delineated by the satellite images (Fig. 3).

In general, there is a remarkable similarity between the patterns seen in the satellite images and the motion of the near-surface drifters.

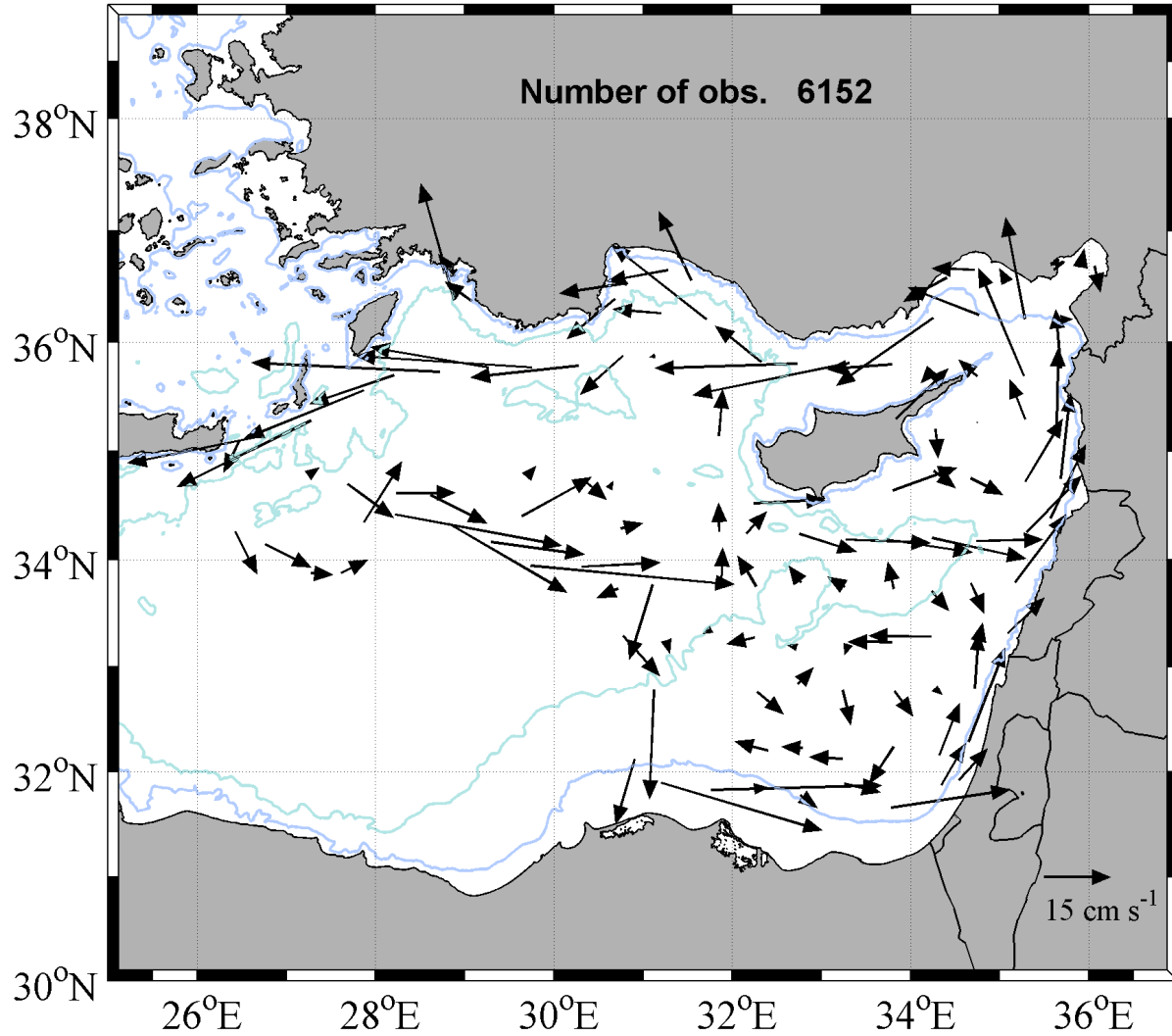


Figure 2. Mean circulation in the Eastern Levantine Sea for the period July 2009 –September 2010. The mean flow arrows are centred at the centre of mass of the observations in each bin. Data are grouped into $0.5^\circ \times 0.5^\circ$ bins. Bins containing less than 5 observations were rejected for the computation of the statistics. The 200 m and 2000 m isobaths are represented with grey curves.

The mean circulation map constructed with the drifter data (Fig. 2) shows a swift coastal current all the way around the Levantine Sea (from the Nile River delta to Crete) with mean velocities reaching 40 cm/s. A westward current prevailing in the central area (more or less connecting Crete to Cyprus) could be the signature of the Mid Mediterranean Jet reported in the literature. Sub-basin scale eddies (south and east of Cyprus, Shikmona) are barely represented in this map due to the smoothing and the scarcity of the data.

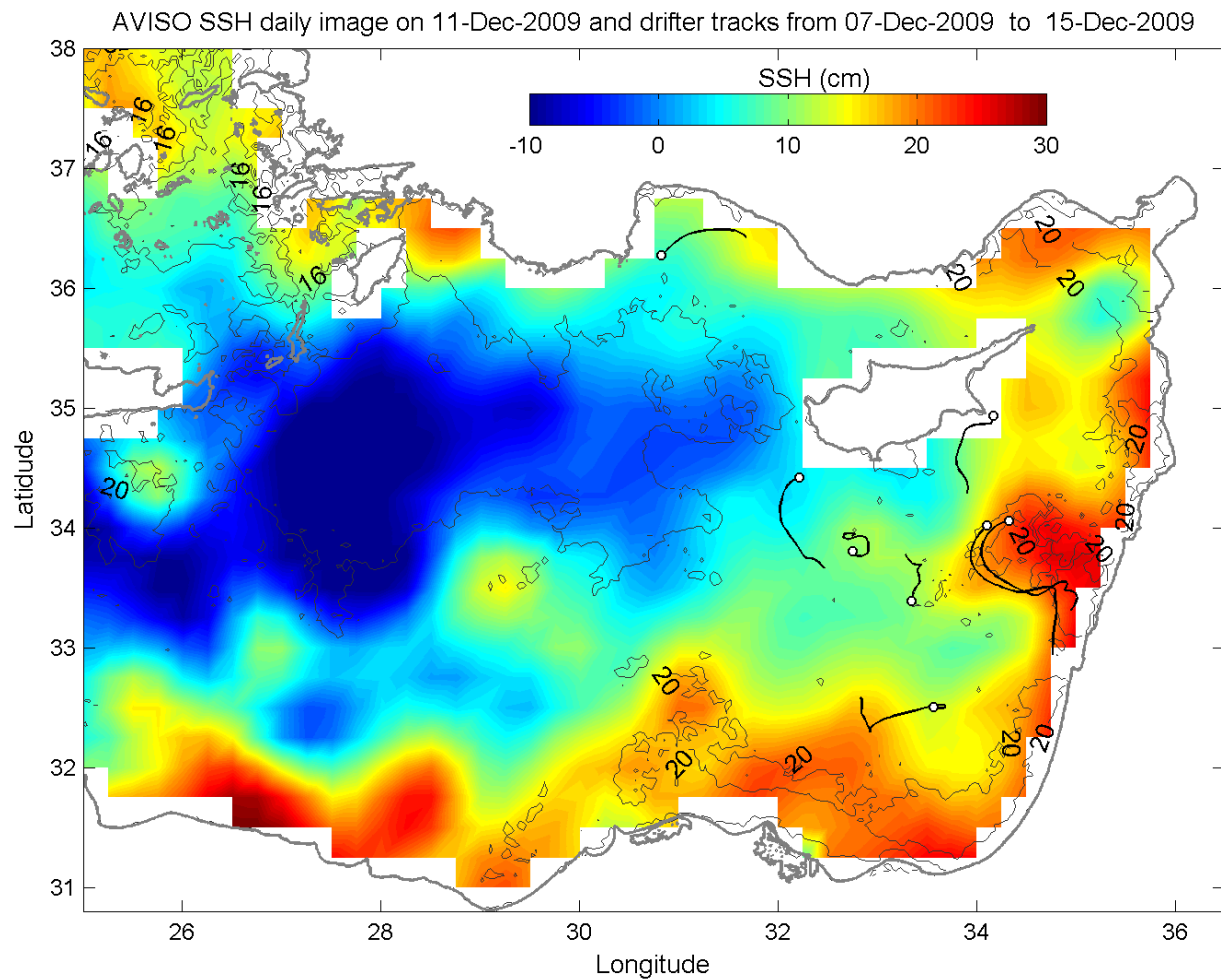


Figure 3. Sea surface height (colors) and sea surface temperature (contour lines with labels in °C) in the Levantine Sea on 11 December 2009. Drifter track segments are overlaid for the period 7-15 December 2009, with the white circle symbols representing the drifter positions at the end of the period.

IMPACT/APPLICATION

The scientific impact of this project is to increase our understanding of the Northeastern Mediterranean Sea dynamics and of its major forcing mechanisms. Future application could be the validation of diagnostic numerical models and the assimilation of the drifter data into prognostic numerical models in the framework of operational oceanography projects (e.g., as part of the Mediterranean Operational Oceanography Network – MOON).

RELATED PROJECTS

In addition to national programs conducted by collaborators in Cyprus, Israel and Turkey, the NEMED project is strongly related to MOON (<http://www.moon-oceanforecasting.eu/>), both in terms of observational activities, such as the Mediterranean Volunteer Observing Ship program (VOS) and the

Mediterranean Argo program (MedArgo; coordinated by the P.I., <http://poseidon.ogs.trieste.it/sire/medargo/>) and nowcasting and forecasting numerical simulations. It is also related to the French project to study the entrapped ecosystem related to the Shikmona or Cyprus eddy as part of the TARA Oceans Expedition (<http://oceans.taraexpeditions.org/>).

PUBLICATIONS

Gertman, I., R. Goldman , Z. Rosentraub , T. Ozer , G. Zodiatis , D. Hayes and P.M. Poulain (2010) Generation of Shikmona anticyclonic eddy from an alongshore current. *Rapp. Comm. int. Mer Médit.*, 39, p. 114.

Poulain, P.M., R. Gerin , M. Menna , I. Taupier-Letage , C. Millot , S. Ben Ismail , C. Sammari , G. Zodiatis and I. Gertman (2010) A Lagrangian view of the Eastern Mediterranean surface circulation over the last two decades. *Rapp. Comm. int. Mer Médit.*, 39, p. 162.